DRAFT

NATURE AND EXTENT DATA REPORT

FOR THE
GULFCO MARINE MAINTENANCE
SUPERFUND SITE
FREEPORT, TEXAS

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1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) named the former site of Gulfco Marine Maintenance, Inc. in Freeport, Brazoria County, Texas (the Site) to the National Priorities List (NPL) in May 2003. The EPA issued a modified Unilateral Administrative Order (UAO), effective July 29, 2005, which was subsequently amended effective January 31, 2008. The UAO required Respondents to conduct a Remedial Investigation and Feasibility Study (RI/FS) for the Site. Pursuant to Paragraphs 17 through 28 of the Statement of Work (SOW) for the RI/FS, included as an Attachment to the UAO, an RI/FS Work Plan and a Sampling and Analysis Plan were prepared for the Site. These documents were approved with modifications by EPA on May 4, 2006 and were finalized on May 16, 2006. This Nature and Extent Data Report (NEDR) has been prepared in accordance with Section 5.6.9 of the approved RI/FS Work Plan (the Work Plan) (PBW, 2006a). The NEDR was prepared by Pastor, Behling & Wheeler, LLC (PBW), on behalf of LDL Coastal Limited LP (LDL), Chromalloy American Corporation (Chromalloy) and The Dow Chemical Company (Dow), collectively, the Gulfco Restoration Group (GRG). Figure 1 provides a map of the Site vicinity, while Figure 2 provides a Site map.

1.1 REPORT PURPOSE

As described in the Work Plan, the purpose of the NEDR is to describe the RI activities that have taken place, and provide Site data documenting the location and characteristics of surface and subsurface features and contamination at the Site including the affected medium, location, types, physical state, concentration and quantity of contaminants, and extent of contaminant migration through affected media. As such, the NEDR is intended to function as the preliminary reference for developing the Baseline Human Health Risk Assessment (BHHRA) and updated Screening-Level Ecological Risk Assessment (SLERA), evaluating the development and screening of remedial alternatives, and refining the identification of applicable or relevant and appropriate requirements (ARARs) in subsequent RI/FS tasks.

Consistent with ongoing project scope discussions and Work Plan descriptions, the NEDR is intended to function as an equivalent document to the Preliminary Site Characterization Report (PSCR) absent any data collected pursuant to a subsequent Ecological Studies Sampling Plan, should any ecological studies be needed. If ecological studies are performed, data from those

studies will be provided in the PSCR, which will supplement the NEDR. If ecological studies are not necessary, the NEDR will serve as the PSCR.

Similar to the description of the PSCR in RI/FS guidance (EPA, 1988), the NEDR is intended to "briefly review the analytical results of investigative activities to provide the lead agency with a reference for evaluating the development and screening of remedial alternatives." The RI/FS guidance notes that the PSCR format may range from a technical memorandum to a more formal report with use of the technical memorandum format strongly encouraged. In light of the multiple media sampled, the number of samples collected, and the comprehensive nature of investigation activities at the Gulfco site, a formal report format for the NEDR has been used. However, consistent with the spirit of the RI/FS guidance, the report has intentionally been limited to a summary of the data obtained with detailed sampling/analytical documentation and descriptions excluded. Furthermore, it is intended that detailed interpretations of the data described herein will be provided in the RI Report, which will be submitted following NEDR approval.

1.2 SITE BACKGROUND

1.2.1 Site Description

The Site is located in Freeport, Texas at 906 Marlin Avenue (also referred to as County Road 756) (Figure 1). The Site consists of approximately 40 acres within the 100-year coastal floodplain along the north bank of the Intracoastal Waterway between Oyster Creek approximately one mile to the east and the Texas Highway 332 bridge approximately one mile to the west. The Site includes approximately 1,200 feet (ft.) of shoreline on the Intracoastal Waterway, a coastal shipping canal that extends from Port Isabel to West Orange on the Texas Gulf Coast.

Marlin Avenue divides the Site into two primary areas (Figure 2). For the purposes of descriptions in this report, Marlin Avenue is approximated to run due west to east. The property to the north of Marlin Avenue (the North Area) consists of undeveloped land and the closed surface impoundments, while the property south of Marlin Avenue (the South Area) was developed for industrial uses with multiple structures, a dry dock, sand blasting areas, an aboveground storage tank (AST) tank farm, and two barge slips connected to the Intracoastal

Waterway. The South Area is zoned as "W-3, Waterfront Heavy" by the City of Freeport. This designation provides for commercial and industrial land use, primarily port, harbor, or marine-related activities. The North Area is zoned as "M-2, Heavy Manufacturing."

Adjacent property to the north, west and east of the North Area is unused and undeveloped. Adjacent property to the east of the South Area is currently used for industrial purposes while to the west the property is currently vacant and previously served as a commercial marina. The Intracoastal Waterway bounds the Site to the south. Residential areas are located south of Marlin Avenue, approximately 300 feet west of the Site, and 1,000 feet east of the Site.

The South Area includes approximately 20 acres of upland that was created from dredged material from the Intracoastal Waterway. Some of the North Area is upland created from dredge spoil, but most of this area is considered wetlands, as per the Wetlands Inventory Map (USFWS, 2008). The Intracoastal Waterway supports commercial barge traffic and other boating activities. The area near the Site is regularly dredged and shoreline habitat is limited.

1.2.2 Site History

The Site's operating history, as constructed through historical aerial photographs, personnel interviews, operating information, investigation report summaries, and regulatory agency correspondence, inspection reports and memoranda/communication records, is discussed in detail in the Work Plan. A summary of that discussion is provided below, with the operational history divided into the following periods:

- Pre-barge cleaning operations (prior to 1971);
- Gulfco Marine Maintenance, Inc. (Gulfco) Operations (1971 – 1979);
- Fish Engineering and Construction, Inc. (Fish) Operations (1979 – 1989);
- Hercules Offshore Corporation and later Hercules Marine Services (collectively referred to as Hercules) Operations (1989 – 1999); and
- LDL Ownership (1999 to present).

The majority of the Site, including Lots 21 through 25, and Lots 55, 57, and 58 (see Figure 2 for approximate lot boundaries) are currently owned by LDL. Lot 56 was not sold to Hercules by Fish in 1989, but was deeded to Jack Palmer and Ron Hudson in 1997.

Pre-Barge Cleaning Operations

The earliest historical photograph of the Site vicinity that could be obtained by PBW was for 1944. That photograph showed the Intracoastal Waterway south of the Site with what appears to be a sloping and somewhat eroded shoreline north of the waterway. Marlin Avenue was not present in 1944; however, a significant linear feature was apparent in the northern part of the Site. This feature may have been a berm or ditch associated with dredge spoiling activities in the area to the south. The berm/ditch feature and Marlin Avenue were present in 1965 as was a canal and future boat slip/marina area on the adjacent property to the west of the Site. According to Mr. Billy Losack (Losack, 2005), off-shore oil platform fabrication work was performed by BEPCO in the northeast part of the South Area during the early 1960s. Raw materials and supplies were brought onto the Site, the platform fabrication work (welding, metals cutting, etc.) was performed, and the finished products and any unused materials/supplies were removed from the Site.

Gulfco Marine Maintenance, Inc. Operations

Gulfco operated a barge cleaning facility on the Site from 1971 to 1979. According to the Hazard Ranking System (HRS) Documentation Record prepared for the Site by TNRCC (TNRCC, 2002), barges brought to the facility were cleaned of waste oils, caustics, and organic chemicals, and the wash waters were reportedly stored in three surface impoundments in the North Area. The impoundments were described as earthen lagoons with a natural clay liner (TNRCC, 2000) and were reportedly three feet deep (Guevara, 1989). Gulfco's operations included two barge slips along the Intracoastal Waterway, a dry dock area used for barge repair, a Site office, a shop and a lunch room building, all in the South Area.

A 1977 aerial photograph showed a commercial marina with covered boat slips and several other surface structures on the property immediately west of the Site. Other undetermined industrial development was indicated on the property east of the Site with a tank farm located approximately 500 feet east of the Site boundary.

Fish Engineering and Construction, Inc. Operations

Fish purchased the Site and barge cleaning operation from Gulfco on November 12, 1979. As described by the TNRCC (TNRCC, 2000), Fish's primary operations consisted of receiving chemical barges, draining the barges and removing the product heels. The barges were washed with hot water and/or detergent solution and air dried prior to any repair work (welding and sandblasting). Barge heels were stored in small tanks with the stored product sold for reuse and recovery. Wash waters were stored in the surface impoundments in the North Area and eventually sent off-site for deep well injection. The impoundments were taken out of service on October 16, 1981 and wash waters were stored in tanks or floating barges thereafter (TNRCC, 2000). The surface impoundments were closed in 1982 in accordance with a Texas Water Commission-approved plan (Carden, 1982). Fish's operations included the dry dock, office, shop, lunchroom/restroom and storage tank areas, an electrical shed, concrete laydown areas, an employee parking area north of Marlin Avenue, and sand pot and air compressor locations.

Hercules Operations

Hercules Offshore Corporation purchased the Site (except for Lot 56) and barge cleaning operation from Fish on January 20, 1989. Subsequently, the Site was conveyed to the entity that became Hercules Marine Services Corporation. These entities are collectively referred to as Hercules. According to the TNRCC (TNRCC, 2000), Hercules' operations included barge cleaning and repair. Product heels were removed from barges into aboveground storage tanks (ASTs) and subsequently sold. Barges were washed with water and detergent. Wash waters were stored in storage tanks and then either transported to an off-site injection well or transported to Empak in Deer Park, Texas (TNRCC, 2000). Site features at the time of Hercules' operations at the Site, as illustrated on a 1995 aerial photograph, included the dry dock, office, shop, electrical shed, lunchroom/restrooms, concrete laydown areas, AST tank farm area, and sand blasting operation areas.

LDL Ownership

LDL acquired the Site (except for Lot 56) from bankruptcy court proceedings on August 2, 1999. Under LDL's direction, most Site operational facilities and equipment were removed from the Site during the initial four months of LDL's ownership (approximately August through

November, 1999). In April 2002, LDL leased part of the Site to Eco-Terra Technologies Group, LLC (ET) who had obtained a Texas Railroad Commission permit to set-up a crude oil recycling operation. ET modified some of the tankage and piping in the former AST Tank Farm area to support this operation, but according to Losack, (2005) only about seven truckloads of crude oil were ever shipped to the Site. ET ceased operations and left the Site after approximately five months.

1.2.3 Previous Investigations

Previous investigations at the Site included the following:

- Surface Impoundment Groundwater Monitoring Wells (1982) – In conjunction with closure of the former surface impoundments in 1982, Fish installed four monitoring wells around the perimeter of the impoundments. All four wells were sampled at least four times from July 1982 through September 1982. The wells were reportedly plugged in December 1983 (TNRCC, 2000). The specific locations of the wells are not known.

- Surface Impoundment Groundwater Monitoring Wells (1989) – In January 1989, Pilko Associates installed three monitoring wells around the perimeter of the former surface impoundments. The approximate locations of these wells, designated as HMW-1, HMW-2, and HMW-3 are shown on Figure 3. The wells were reportedly screened from 8 to 18 feet below grade (Hercules, 1989).

- Groundwater Monitoring Wells (the South Area) – Three permanent monitoring wells (PVC well casing, outer steel protective casing) are present in the South Area (MW-1, MW-2 and MW-3 on Figure 3). The construction details and installation dates for these wells are not known, although the total depths are reported to range from 15.2 to 20.3 feet below grade (TNRCC, 2000). The wells were sampled by LT Environmental, Inc. (LTE) in 1999 and the TNRCC in 2000 (see below).

- ECM Phase I and II Investigations (1998 - 1999) – According to LTE (1999), ECM & Associates (ECM) performed Phase I and II investigations at the Site that were summarized in a Phase II Sampling Report dated January 27, 1999. This report is not available and thus its scope and conclusions as reported in LTE, 1999 could not be confirmed. LTE (1999) noted several ECM investigation findings that served as a basis for subsequent Site characterization work performed by LTE.

- LTE Site Characterization (1999) – In March 1999, LTE performed a series of investigation activities at the Site, including sampling AST and drum contents, accumulated water within the former AST tank farm containment area, soils, residual sandblasting material, sediment from an on-site pond (“the Fresh Water Pond”), and groundwater. Groundwater samples included samples from temporary monitoring wells installed by LTE and samples from previously existing wells MW-1, MW-2, and MW-3.

- TNRCC Screening Site Inspection (2000) – In cooperation with the EPA, TNRCC performed a Screening Site Inspection (SSI) at the Site in 2000 (TNRCC, 2000). The SSI included collection of on-site and off-site soil samples, Intracoastal Waterway sediment samples (adjacent to and distant from the Site), Pond sediment samples and groundwater samples from existing monitoring wells MW-1, MW-2 and MW-3.

- TNRCC Expanded Site Inspection 2001 –In cooperation with EPA, TNRCC performed an Expanded Site Inspection (ESI) in January 2001. The ESI included collection of groundwater samples from temporary on-site and off-site monitoring wells. Although a separate ESI report was not prepared, the findings of the ESI were included in the HRS Documentation Record (TNRCC, 2002).

In addition to these investigation activities, a Public Health Assessment (PHA) of the Site was prepared by the Texas Department of Health (TDH) for the Agency for Toxic Substances and Disease Registry (ATSDR) (TDH, 2004). The PHA concluded that contaminants in soil, sediment and groundwater pose no apparent public health hazards, but the overall public health hazard could not be determined due to a lack of data for all pathways.

1.3 REPORT ORGANIZATION

As provided in Section 2.0 below, the Site investigation data are generally discussed by geographic area (e.g. Intracoastal Waterway, North Area, South Area) and by specific environmental media (e.g. soil, sediment, etc.) within those areas. Groundwater data are discussed separately within Section 2.0. Consistent with NEDR objectives, the Section 2.0 discussions focus on documenting the extent of contamination within each of the Site environmental media. References cited in this report are listed in Section 3.0.

2.0 STUDY AREA INVESTIGATION

2.1 INTRODUCTION

Site investigation activities were performed using a phased approach for each environmental medium investigated. The first investigative phase for each medium involved the collection of environmental samples from that medium at locations specified in the Work Plan, or, in some cases, at initial locations jointly determined by GRG and EPA representatives. The scope of subsequent investigational phases (where applicable) were developed on the basis of the initial data as described below. Sample collection methods, field measurements procedures, laboratory analytical methods and data validation procedures were specified in the Field Sampling Plan (FSP) (PBW, 2006b) and the Quality Assurance Project Plan (QAPP) (PBW, 2006c). Field activities were performed in accordance with the Site-specific Health and Safety Plan (PBW, 2005).

2.1.1 Data Validation Process

Consistent with QAPP procedures, data validation was performed on 100% of the environmental samples. Analytical results presented in this report include the QAPP-specified data validation qualifiers, which are defined as follows:

none	No QC deficiencies noted.
J	The analyte is confirmed present, but the reported value is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The reported value is an estimated quantity, and the result may be biased high.
J-	The reported value is an estimated quantity, and the result may be biased low.
R	The data are not usable due to serious deficiencies in meeting quality control criteria. The analyte may or may not be present in the sample.
U	Analyte was not detected above 5x (10x for common contaminants) the level in an associated blank.
UJ	Analyte not detected at or above the sample detection limit, but the reported limit is an estimated quantity. The associated numerical value is an approximate concentration that may be inaccurate or imprecise.
NJ	Analyte tentatively identified. Presence of the analyte is not confirmed and the reported value is an estimated quantity.

A data validation qualifier of J may be assigned solely because the analytical result was qualified by the laboratory as an estimated concentration between the sample detection limit and the sample quantitation limit. When an option exists to assign two different flags, the flag higher in the data quality hierarchy was assigned (R > UJ > U > NJ > J > J+ or J-).

The completeness, which is the percentage of valid measurements obtained, was calculated for each medium and compared to the goals established in the QAPP (90% on a sample level and 80% on an analyte level). The completeness goal on a sample level was met for all media. The completeness goal on an analyte level was met for all media, except the following:

- Benzidine in Surface Water (77% completeness) and Groundwater (67% completeness) – This analyte is known to be subject to oxidative losses during solvent concentration and to poor chromatographic behavior. Low completeness does not limit data usability since the analyte was not detected in any of the surface water or groundwater samples with a valid measurement.

- Benzoic Acid in Surface Water (77% completeness) and Groundwater (59% completeness) – This analyte is also known to exhibit poor (non-reproducible) chromatographic performance. Low completeness does not limit data usability since the analyte was not detected in any of the surface water or groundwater samples with a valid measurement.

- 2-Chloroethylvinylether in Surface Water (0% completeness) and Soils (34% completeness) – This analyte is known to be a reactive compound that readily breaks down under acidic conditions such as in acid-preserved aqueous samples. It is also subject to hydrolysis catalyzed by acidic sites in clay soils and to biodegradation in soil. Low completeness does not limit data usability since the analyte was not detected in other media and is not historically associated with the Site.

- Hexavalent Chromium in Sediments (32% completeness) and Soils (3% completeness) – This analyte was inadvertently not measured by the laboratory for most of the Phase 1 sediment and soil samples. Low completeness does not limit data usability since total chromium, which includes any hexavalent chromium, was measured for all affected samples.

- Pyridine in Surface Water (68% completeness) – This analyte is known to be subject to poor performance at the temperatures for the gas chromatograph injection port specified in the analytical method. Low completeness does not limit data usability since the analyte was not detected in any of the surface water samples with a valid measurement.

2.1.2 Data Evaluation Process

Following validation, data from an initial investigation phase were compared to Preliminary Screening Values (PSVs) specified in the Work Plan and background levels (as appropriate for that specific medium and chemicals of interest) for the purpose of assessing whether the lateral and (for most media) vertical extent of chemicals of interest (COIs) in the environmental medium being evaluated had been identified. In cases where perimeter samples contained one or more COIs exceeding both their respective PSVs and background levels (where applicable), additional investigative phases were proposed in accordance with Work Plan provisions. The scope of an additional investigative phase, and the PSV/background exceedences requiring additional investigation were typically proposed in a letter to EPA. Following discussion/resolution of EPA comments (if any) and subsequent EPA approval, the proposed work was performed. After the resultant data were validated and compared to PSVs/background, additional investigation phases were proposed if warranted. This process was repeated as necessary until no PSV/background exceedences associated with the Site were indicated in subsequent perimeter (horizontal and vertical, depending on medium) samples. For some media, such as Intracoastal Waterway surface water, only a single investigative phase was required. For other media, such as groundwater, multiple investigative phases were performed.

Site investigative activities are described by medium and/or area in the sections below. The text of each section provides a discussion of PSV/background exceedences with supporting tables and figures demonstrating how the lateral and vertical (where appropriate) extent of COIs has been identified. The Site database, which includes all laboratory analytical data, is provided in electronic form (on DVD) in Appendix A of this report. Electronic copies of the analytical laboratory and data validation reports (grouped by media and then laboratory sample delivery group) are also provided in Appendix A. Correspondence related to the proposal and approval of various investigation phases is listed in Table 1. All investigation sample locations, except background samples, are shown on Plate 1.

2.2 SURFACE GEOPHYSICS EVALUATION

In accordance with Section 5.6.2 of the Work Plan, a surface geophysical survey was performed to attempt to locate former pipelines at the Site that may have been used to transport product material or wash water associated with the barge cleaning process from the barges and former

AST Tank Farm to the former surface impoundments or to former wash water storage tanks located to the east of the AST Tank Farm. As part of this survey, an electromagnetic (EM) metal detector and an EM radiodetection (RD) meter were used to evaluate magnetic anomalies caused by buried metal.

The surface geophysical survey was performed on June 27 and 28, 2006. EM and RD data were collected along twenty-two transects (Figure 4). The EM data (contoured on Figure 4) suggested the presence of a pipeline between the AST Tank Farm area and the former surface impoundments in the North Area. The northern end of this pipeline was observed aboveground just south of the former surface impoundments. EM data anomalies suggesting the pipeline location were not contiguous to the north of Marlin Ave and the surface expression of the pipeline showed some corrosion, suggesting that the pipeline was largely deteriorated. In an attempt to confirm the specific pipeline location, the exposed northern pipeline section was induced with a radio frequency and the area where the pipeline was suspected to be present was subsequently scanned with an RD meter. The induced RD detections, which are shown as a series of individual RD detection points on Figure 4, provide an approximate projection of the pipeline location. Based on this information, the appropriateness of Site investigation sample locations proposed in the Work Plan near the previously assumed pipeline location was confirmed.

The EM survey also indicated several EM data anomalies to the east of the AST Tank Farm (Figure 4). It is likely that these anomalies were caused by the presence of concrete slabs with metal plates on the slab surface. The data did not suggest the presence of any underground pipelines to the east of the AST Tank Farm.

2.3 INTRACOASTAL WATERWAY

2.3.1 Sediments

Intracoastal Waterway sediments were investigated through the collection and analysis of nine samples from a background area and 17 samples adjacent to the Site. All samples were collected from the 0 to 0.5 foot depth interval as specified in the Work Plan and in the FSP. The background sample locations (IWSE21 through IWSE29) are shown on Figure 5 and the Site sample locations (IWSE01 through IWSE16, and IWSE34) are shown on Figure 6. In addition to the 17 sampled Site locations, multiple attempts were made to collect samples at two additional

Site locations (IWSE35 and IWSE36) on Figure 6; however, sufficient sediment thickness for an adequate sample (as jointly determined by GRG and EPA representatives) was not present at these locations.

In accordance with Work Plan provisions for evaluating the lateral extent of COIs in Intracoastal Waterway sediment near the Site, chemical concentrations in perimeter Site sediment samples were compared to PSVs and background data on an individual sample basis. PSVs listed in Table 21 of the Work Plan, as updated to reflect changes in human health or ecological toxicity values since preparation of the Work Plan, were used in these comparisons. Background values used for these comparisons were calculated from the Intracoastal Waterway background sediment sample data using the tolerance interval approach described in EPA's Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (EPA, 2002). Only certain metals were detected at a sufficient frequency in the background sediment samples to warrant development of a background value. Calculation details for these background Intracoastal Waterway sediment values are provided in Appendix B. The PSVs and background values considered for evaluating the lateral extent of COIs in Intracoastal Waterway sediment are listed in Table 2. Consistent with Work Plan provisions, the extent evaluation comparison values listed in this table represent the higher of either the PSV or background value (where applicable) for each COI.

As shown in Table 3 and on Figure 7, one or more COIs (4,4'-DDT and certain polynuclear aromatic hydrocarbons, or PAHs) were detected at concentrations exceeding their respective comparison values at five Site sediment sample locations. Approximately two-thirds of these exceedences have a "J" data qualifier indicating an estimated concentration, typically between the sample detection limit and the sample quantitation limit. All five exceedence locations were within or on the perimeter of the barge slip areas. The lateral extent of COIs in sediment at these locations is defined by location IWSE34 to the west, where 4,4'-DDT (the sole exceedence at location IWSE01) was not detected, locations IWSE35 and IWSE36 to the south, where as noted previously, a sufficient sediment thickness for sample collection was not present, and locations IWSE06, IWSE09, and IWSE10 to the east, where no exceedences were observed.

2.3.2 Surface Water

Intracoastal Waterway surface water was investigated through the collection and analysis of four samples from a background area and four samples adjacent to the Site. All samples were composites consisting of three sub-samples (one sub-sample from approximately one foot below the water surface, a second sub-sample from the mid-depth of the water column, and a third sub-sample from approximately one foot above the base of the water column). Samples were collected using tubing and a peristaltic pump as specified in the Work Plan and in the FSP. The background sample locations (IWSW30 through IWSW33) are shown on Figure 5 and the Site sample locations (IWSW17 through IWSW20) are shown on Figure 6.

In accordance with Work Plan procedures for evaluating the lateral extent of COIs in Intracoastal Waterway surface water near the Site, chemical concentrations in surface water samples were compared to PSVs on an individual sample basis. PSVs listed in Table 20 of the Work Plan, as updated to reflect changes in human health or ecological toxicity values since preparation of the Work Plan, were used in these comparisons. Based on the absence of any COIs exceeding PSVs in Intracoastal Waterway surface water samples adjacent to the Site, background surface water values were not calculated for this comparison. Thus, the extent evaluation comparison values listed in Table 4 reflect the lowest updated PSVs from Table 20 of the Work Plan. It should be noted that aldrin and dissolved silver concentrations in samples from all four background sample locations (IWSW30 through IWSW33) exceeded their respective extent evaluation comparison values. Concentrations of 4,4'-DDD and 4,4'-DDT in the sample from background location IWSW33 also exceeded their respective extent evaluation comparison values.

2.3.3 Fish Tissue

Based on the analytical results for the Intracoastal Waterway sediment samples and in accordance with Section 5.6.8 of the Work Plan, fish tissue samples were collected from four Site zones (Figure 6) and one background area (Figure 5) within the Intracoastal Waterway. Red drum (*Sciaenops ocellatus*) (6 samples), spotted seatrout (*Cynoscion nebulosus*) (9 samples), southern flounder (*Paralichthys lethostigma*) (9 samples), and blue crab (*Callinectes sapidus*) (9 samples) samples were collected from the Site for laboratory analysis. Samples of these species were also collected from the background area and were archived.

The Site fish tissue samples were analyzed for 12 COIs, based on Intracoastal Waterway sediment data, in accordance with EPA's November 14, 2006 letter. Table 5 contains a summary of the analytical results for the 33 fish tissue samples collected. The only COIs with concentrations measured above sample detection limits in any of these samples were silver (detected in four samples), benzo(b)fluoranthene (detected in two samples), and 4,4'-DDE (detected in two samples). The fish tissue data were used to calculate potential risks associated with exposure to Site COIs via the fish ingestion pathway to recreational anglers fishing at the Site, or their families. This risk assessment (presented in a March 20, 2007 letter to EPA) concluded that the fish ingestion pathway does not pose a human health threat. That conclusion was subsequently approved in a June 29, 2007 letter from EPA.

2.4 SOUTH AREA

In addition to groundwater investigations described on a Site-wide basis in Section 2.6 below, investigations in the South Area consisted of the two separate soil programs with differing scopes and objectives, as specified in the Work Plan. The first program involved the collection of soil samples from multiple depth intervals for evaluating the lateral and vertical extent of COIs in Site soils. This program is referred to as the "south area soil investigation". The second program, which was limited to the collection of surface soil samples (0 to 1-inch depth interval) from the western part of the South Area and off-site properties immediately west of the South Area, had the focused objective of evaluating the potential for migration of metals associated with Site sandblasting operations to produce elevated concentrations in soils in residential areas to the west. Consistent with the terminology in the Work Plan, this program will be referred to as the "residential surface soil investigation". Descriptions of each program and its findings are provided below.

2.4.1 South Area Soil Investigation Program

In accordance with Section 5.6.3 of the Work Plan, Phase 1 soil samples were collected for chemical analysis from the 0 to 0.5 ft and 1 to 2 foot depth intervals from 85 locations in the South Area. Based on data from these initial Phase 1 samples (discussed below), Phase 2 soil samples were collected from the 4 to 5 foot depth interval from 15 additional locations from the South Area and from various depth intervals at seven locations on the adjacent former commercial marina parcel to the west (also referred to as "Lot 20").

In accordance with the Work Plan provisions, the analytical data from the Phase 1 samples were used to evaluate the extent of contamination at the Site, and assess the need for additional soil sampling activities. This evaluation entailed a comparison to PSVs for soil as listed in Tables 15 or 16 of the Work Plan (depending on sample location), subject to a comparison to background concentrations, as determined from Site-specific background samples or Texas-specific background concentrations provided in 30 TAC 350.51(m). The following Phase 1 soil data were used in this evaluation:

(1) Western Extent of Contamination - Analytical data for the 0 to 0.5 foot and 1 to 2 foot depth interval samples from the westernmost grid column of the South Area sample grid (Grid Column A as shown on Figure 8) were used to evaluate the western extent of contamination.

(2) Eastern Extent of Contamination - Analytical data for the 0 to 0.5 foot and 1 to 2 foot depth interval samples from the easternmost grid column of the South Area sample grid (Grid Column L as shown on Figure 8) were used to evaluate the eastern extent of contamination in the South Area.

(3) Vertical Extent of Contamination - Analytical data for the 1 to 2 foot depth interval samples from all locations were used to evaluate the vertical extent of contamination at the Site.

The southern extent of potential soil contamination is defined by the Intracoastal Waterway since it bounds the physical extent of soil on the southern end of the South Area. The northern extent of potential soil contamination in the South Area is similarly defined by Marlin Avenue, whose construction occurred prior to industrial operations in the South Area, and the North Area of the Site, which primarily consists of wetland areas and the former surface impoundments.

Site-specific background soil data were obtained from ten surface soil samples collected from within the EPA-approved background area approximately 2,000 feet east of the Site near the east end of Marlin Avenue (see Figure 9). These background samples were analyzed for pesticides, semi-volatile organic compounds (SVOCs), and selected metals (antimony, arsenic, barium, chromium, copper, lead, lithium, manganese, mercury, molybdenum, and zinc). Pesticides, SVOCs, antimony and cadmium were not detected at sufficient frequencies in background soil samples to warrant the development of Site-specific background values for these COIs. Site-specific background values were developed for all other metals for which background soil samples were analyzed.

In order to evaluate the extent of contamination, chemical concentrations in Phase 1 perimeter samples (both horizontal and vertical as encompassed by the three data sets described above) were compared to PSVs and background data on an individual sample basis. Consistent with the approach described previously for Intracoastal Waterway sediment samples, tolerance limits were calculated for the Site-specific background metal analytes, as proposed in GRG's September 11, 2007 letter and approved by EPA's October 30, 2007 letter. The original zinc background calculation described in the September 11, 2007 letter was based on the removal of the three highest zinc results from the background data set prior to the tolerance limit calculation. Following additional review of the data and discussion with EPA on June 17, 2008, it was agreed that the lower of these three results should be included in the tolerance limit calculation. The revised zinc calculation using these data, along with the previous calculations for other metals from the September 11, 2007 letter, is provided in Appendix C. These background values were used in the evaluation of the three perimeter soil sample data groups as described below.

Western Extent of Soil Contamination Evaluation

As noted above, the western extent of soil contamination in the South Area was evaluated based on analytical data for the 0 to 0.5 foot and 1 to 2 foot depth interval samples from the westernmost grid column of the South Area sample grid (Grid Column A on Figure 8). As shown in Table 6, the comparison values for each COI are the higher of its PSV or background value (where applicable). The PSVs listed in Table 6 are from Table 16 of the Work Plan, as updated to reflect changes in human health or ecological toxicity values since preparation of the Work Plan. The background values listed in Table 6 are the Texas-specific background concentrations provided in 30 TAC 350.51(m) and the Site-specific background values determined as described above and listed in Appendix C.

Detected soil concentrations in western perimeter samples (i.e., Grid Column A locations) that exceed the Table 6 comparison values are listed in Table 7 and are shown on Figure 10. Based on these data, samples were collected from seven locations from Lot 20, the former commercial marina parcel to the west of the Site. Several exceedences were noted in these Lot 20 samples ("Phase 2 samples" as listed in Table 7) and shown on Figure 10. A review of the Lot 20 and Grid Column A data suggests the presence of an off-site contaminant source in the vicinity of sample locations L20SB06 and L20SB07, where concentrations of several COIs (particularly lead

and zinc) were significantly higher than concentrations observed in adjacent South Area samples. As shown on Figure 10, location L20SB07 is at the edge of a dry dock facility associated with the former commercial marina. Regardless of the source of the exceedences at locations L20SB04 through L20SB07, the western extent of potential soil contamination is bound by the former commercial marina boat slip area to the west which is the physical extent of soil west of these samples. The benzo(a)pyrene (BaP) concentration in the 0 to 0.5 foot depth interval sample at L20SB01 is also believed to be associated with an off-site source since no BaP exceedences were observed in multiple depth samples from sample locations L20SB02 and L20SB03, which are between the South Area and L20SB01. The lead exceedence at L20SB01 (estimated concentration of 19 mg/kg) is only slightly above the Site-specific background lead value of 17.9 mg/kg and is also believed to be associated with an off-site source based on a lead concentration of 462 mg/kg in a nearby surface sample (L20SS04) collected as part of the residential surface soil investigation described below. Based on this evaluation, it is concluded that the western extent of soil contamination in the South Area has been defined.

Eastern Extent of Soil Contamination Evaluation

The eastern extent of soil contamination in the South Area was evaluated based on analytical data for the 0 to 0.5 foot and 1 to 2 foot depth interval samples from the easternmost grid column of the South Area sample grid (Grid Column L on Figure 8). As proposed in GRG's September 11, 2007 letter and approved by EPA's October 30, 2007 letter, ecological PSVs were not considered for the eastern extent evaluation because the property east of the South Area is an operating industrial facility with no appreciable ecological habitat. Thus, the comparison values in Table 8, which include PSVs from Table 15 of the Work Plan with the ecological PSVs removed, were used for this evaluation. As in Table 6, the comparison values for each COI in Table 8 are the higher of its PSV or background value (where applicable). No detected concentrations in the eastern perimeter samples (i.e., Grid Column L locations) exceeded the Table 8 comparison values. Based on this evaluation, it is concluded that the eastern extent of soil contamination in the South Area has been defined.

Vertical Extent of Soil Contamination Evaluation

The vertical extent of soil contamination in the South Area was evaluated based on Phase 1 analytical data for the 1 to 2 foot depth interval samples from all locations in the South Area. As

described in GRG's September 11, 2007 letter and approved by EPA's October 30, 2007 letter, ecological PSVs were not considered for the vertical extent evaluation because Site soil conditions suggest that there is limited potential for significant biological activity below a depth of two feet and representative Site ecological receptors typically do not burrow below this depth. Based on these considerations, human health PSVs (as reflected in Table 8) were used (with background) for the vertical extent of soil contamination evaluation. It should be noted, however, that the Site soil data will be used, as appropriate, in a forthcoming update to the Site Screening-Level Ecological Risk Assessment.

Table 9 lists the detected soil concentrations in the Phase 1 samples that exceed the Table 8 comparison values. Based on these data, deeper soil samples were collected from the 4 to 5 foot depth interval at the 15 locations and analyzed as listed in Table 10. No extent evaluation comparison value exceedences were detected in any of these 15 samples, thus it is concluded that the vertical extent of soil contamination in the South Area has been defined.

2.4.2 Residential Surface Soil Investigation Program

In addition to soil sampling for nature and extent purposes, soil samples were also collected as part of a residential surface soil investigation program designed to evaluate the potential for migration of metals associated with Site sandblasting operations to produce elevated concentrations in soils in residential areas to the west. As specified in Section 5.6.3 of the Work Plan, this investigation included the collection of surface soil samples for chemical analysis from the 0 to 1 inch depth interval at 27 specified locations on off-site Lots 19 and 20 (see Figure 11 for sample locations). The analytical suite for these samples was determined through an evaluation of data for 0 to 1 inch and 0 to 0.5 foot depth interval samples from on-site Lots 21, 22 and 23 as detailed in the Work Plan (Site lot designations are shown on Figure 2). Based on this evaluation, which was detailed in GRG's August 20, 2007 letter to EPA (approved with modification on September 6, 2007 and resubmitted on September 21, 2007), the 27 surface soil samples collected from off-site Lots 19 and 20 were analyzed for lead.

Lead concentrations in the Lot 19/20 surface soil samples are listed in Table 11 and plotted on Figure 11. Consistent with the data evaluation approach described in GRG's August 20, 2007 letter to EPA, these data were compared to the lowest of the lead PSVs in Table 17 of the Work Plan that are associated with direct contact exposure pathways (i.e., those pathways involving

potential soil contact by residential receptors). The lead PSVs for these pathways are the EPA Region 6 human health media-specific screening level for soil of 400 mg/kg, and the TCEQ $^{Tot}Soil_{Comb}$ Protective Concentration Level (PCL) of 500 mg/kg, which includes inhalation, ingestion and dermal pathways. Thus, a lead concentration of 400 mg/kg was used as the comparison value for assessing whether further surface soil investigation beyond Lots 19 and 20 was necessary.

The sole Lot 19/20 surface soil sample with a lead concentration greater than 400 mg/kg was sample L20SS04 (462 mg/kg). As shown on Figure 11, this sample was collected adjacent to a concrete slab (and the location of a former building) associated with former commercial marina operations on Lot 20 described previously. This lead concentration is believed to be indicative of a local source associated with the former marina rather than a source at the Gulfco site. As shown on Figure 11, lead concentrations in Lot 20 surface soil samples (0 to 1 inch depth interval) collected between L20SS04 and the Gulfco site (i.e., samples L20SS05 and L20SS06) were below or near the lead background concentration of 17.9 mg/kg, and thus far below the L20SS04 result or similarly elevated lead concentrations that would be expected if the Gulfco site were a source of elevated lead to this area. Regardless of the source of the lead concentration at L20SS04, the lead concentrations in surface soil samples between L20SS04 and Snapper Lane to the west (as indicated by the data for samples L19SS01, L19SS02, L19SS08, L19SS09, L19SS15, and L20SS01 as shown on Figure 11) were all far below the 400 mg/kg comparison value, thus precluding the need for further residential soil investigation sampling. Lead concentrations in the seven westernmost surface soil sample locations near Snapper Lane (samples L19SS01 through L19SS07 as shown on Figure 11) were all below or near the background lead concentration (17.9 mg/kg), further demonstrating the absence of impacts to soil in this area.

2.5 NORTH AREA

As noted previously, most of the North Area consists of wetlands, with upland soils limited to the area between the former surface impoundments and Marlin Avenue. Two ponds are also present within this area. In addition to groundwater investigations described on a Site-wide basis in Section 2.6 below, investigations in the North Area consisted of an evaluation of the former surface impoundments cap, and investigations of soils, wetland sediments, wetland surface water,

ponds sediments and ponds surface water. Descriptions of each of these investigations and its findings are provided below.

2.5.1 Former Surface Impoundments Cap

In accordance with Section 5.6.1 of the Work Plan, Site investigation activities included an evaluation of the construction materials and thickness of the clay caps constructed on the former surface impoundments. This evaluation involved drilling and sampling of four borings through the caps, geotechnical testing of representative cap material (clay) samples, and performance of a field inspection of the caps, including observation of desiccation cracks, erosion features, and overall surface condition. The location of the cap geotechnical soil borings are shown on Figure 12.

As shown in Table 12, the surface impoundment cap thicknesses at the four boring locations ranged from 2.5 feet to greater than 3.5 feet. The geotechnical properties (Atterberg Limits, and Percent Passing # 200 Sieve) of the cap material as listed in Table 12 are consistent with those recommended for industrial landfill cover systems in TCEQ Technical Guideline No. 3 (TCEQ, 2004) and the vertical hydraulic conductivities were all better (i.e., less) than the TCEQ guideline of 1×10^{-7} cm/sec.

The cap field inspection was performed on August 3, 2006. The cap appeared to be in generally good condition with no significant desiccation cracks or erosion features observed on the cap surface or slopes. The cap surface consisted of a partially vegetated crushed oyster shell surface overlying the clay layer. Some sporadic indications of animal (e.g., crab) penetrations of the cap surface were observed. Occasional debris (e.g., scrap wood and telephone poles) was observed on the surface and several large bushes (approximate height of three feet) were observed, mostly near the cap edges. Drilling rig and other heavy equipment (i.e. support truck) traffic across the western end of the cap in conjunction with Site investigation activities has resulted in surface rutting of the cap in this area.

2.5.2 North Area Soil Investigation

In accordance with Section 5.6.3 of the Work Plan, North Area Phase 1 soil samples were collected for chemical analysis from the 0 to 0.5 ft and 1 to 2 foot depth intervals from 14 upland

locations. Since the physical extent of soil in the North Area is bound by the surrounding wetland areas (where wetland sediment samples were collected as described in Section 2.5.3, below), the lateral extent of potential soil contamination in the North Area was effectively determined by the lateral extent of soil. Similar to the vertical extent evaluation of South Area soils described in Section 2.4.1, the vertical extent of contamination in North Area soils was evaluated through a comparison of Phase 1 soil data from the 1 to 2 foot depth interval samples to the extent evaluation comparison criteria listed in Table 6. Vertical extent evaluation criteria were exceeded at only one North Area soil sample location, ND3SB04. Based on this exceedence, a Phase 2 soil sample was collected from the 4 to 5 foot depth interval at this location.

In addition to this Phase 2 sample, three shallow soil borings (SB-201, SB-202, and SB-203 on Figure 12) were advanced at locations where scrap metal was observed at the ground surface. Soil samples were collected for laboratory analysis from the 0 to 0.5 foot and 1.5 to 2.0 foot depth intervals from these three borings. Three additional Phase 2 borings (SB-204, SB-205, and SB-206) were advanced in the vicinity of Phase 1 soil boring NE3SB09 (see Figure 12), where subsurface debris (e.g., a section of rope) was observed in the auger cuttings from the boring for adjacent monitoring well NE3MW05, in order to evaluate the presence and/or composition of debris in this area. Soil samples for laboratory analyses were collected from multiple depth intervals from these three borings, generally corresponding to one foot depth intervals immediately above observed debris, immediately below the debris, and within the approximate center of the observed debris layer.

Table 13 and Figure 12 list detected soil concentrations in the North Area soil samples that exceed the Table 6 comparison values. In most cases where an exceedence was noted, a deeper soil sample with no comparison value exceedences served to define the vertical extent of contamination. At boring locations ND3SB04 and SB-206, exceedences were noted in the deepest sample collected (4 to 5 foot and 5 to 6 foot depth intervals, respectively); however, in accordance with Work Plan provisions that soil samples need not be collected from depths below either: (1) the water table; or (2) the surface soil depth at the sample location as defined in 30 TAC 350.4(a) (88) (i.e., five feet), deeper sampling was not performed.

At boring SB-205, debris was observed from approximately three to six feet below ground surface (bgs). Given the depth of the debris relative to the saturated zone (saturated conditions were observed at a depth of approximately 4 to 5 feet), it was decided (with EPA concurrence) to

not attempt to collect a sample below the debris at this location. Thus, sampling was not performed below the 3 to 4 foot depth interval sample although iron and lead concentrations in this sample exceeded their respective comparison values (Table 13).

The laboratory was unable to analyze the 3 to 4 foot depth interval sample (the debris interval sample) at boring location SB-205 for organic analytes due to solidification of the sample extracts during the concentration step of the analyses. Such solidification is consistent with olfactory and visual indications of naphthalene in this sample at the time of collection. As indicated by the absence of naphthalene exceedences in nearby SB-204 and SB-206 samples (Table 13), and the lack of visual and olfactory indications of naphthalene observed during the drilling of those borings, the area containing naphthalene in buried debris or adjacent soils appears limited to the vicinity of SB-205.

Borings SB-201 through SB-203 were drilled at EPA's request to evaluate the possible presence of subsurface debris in this vicinity where scrap metal materials were present on the ground surface. As shown in Table 13, the only metals concentrations above their respective comparison criteria in these borings were iron and lead in the 0 to 0.5 foot depth sample from SB-202. BaP was reported above its comparison value in the 1.5 to 2.0 foot sample from SB-203, but was not detected in the 0 to 0.5 foot sample at this location. Based on the SB-201 through SB-203 concentration data and visual observations from these borings, which did not indicate the presence of significant subsurface debris, no further investigation of this area was performed.

2.5.3 Wetland Sediments

In accordance with Section 5.6.7 of the Work Plan, wetland sediment samples were initially collected for chemical analysis from the 0 to 0.5 foot depth interval at 17 grid-based locations (locations with sample suffix designations "–SE01" through "–SE17" as shown on Figure 13). At 10 of these locations, where saturated conditions were not encountered at depths less than 2 feet, samples were also collected from the 1 to 2 foot depth interval. In addition, 17 Phase 2 wetland sediment samples (2WSED1 through 2WSED17 on Figure 13) were collected from on-site and off-site locations selected (with concurrence from EPA) based on field observations, particularly with regard to potential drainage areas.

In accordance with the Work Plan provisions, the analytical data from these samples were used to evaluate the lateral extent of contamination in wetland sediments, and assess the need for additional wetland sediment sampling. This evaluation entailed a comparison to PSVs for sediment as listed in Table 21 of the Work Plan, subject to a comparison to background concentrations. Given the similar composition and condition of the surface soils collected from within the approved background soil area to the wetland sediments in the North Area, the Site-specific background values determined from those soil samples, as described in Appendix C, were used to represent background wetland sediment concentrations for the purposes of evaluating the lateral extent of contamination. As shown in Table 14, the comparison value for each COI is the higher of its PSV or background value (where applicable). The PSVs listed in Table 14 are from Table 21 of the Work Plan, as updated to reflect changes in human health or ecological toxicity values since preparation of the Work Plan. The background values listed in Table 14 are the Site-specific background values determined as described above.

Based on an evaluation of data for the outermost Phase 1 and 2 wetland sediment samples relative to the extent evaluation comparison values in Table 14, ten additional samples (locations 3WSED1 through 3WSED9, and 4WSED1 on Figure 13) were collected. Two other locations (4WSED2 and 4WSED3) were also sampled at EPA's request.

Detected COI concentrations in wetland sediment samples that exceed the Table 14 comparison values are listed in Table 15 and plotted on Figure 13. As shown on this figure, extent evaluation comparison values were not exceeded in any of the outermost wetland sediment samples. Therefore, it is concluded that the lateral extent of contamination in wetland sediment to the west, north and south and east has been identified. The physical extent of wetland sediments (and thus potential contamination in wetland sediments, as well) is bound by Marlin Avenue and South Area soils to the south.

2.5.4 Wetland Surface Water

Section 5.6.6 of the Work Plan specified the collection of surface water samples from 15 locations (both on-site and off-site) within the wetlands north of Marlin Avenue. Based on field reconnaissance and subsequent discussions with EPA during 2006 (Table 1), the number of proposed surface water sample locations was subsequently revised to six locations due to the general lack of ponded surface water in the area. Sampling at these locations was performed on

December 6, 2006. Surface water was not present at two sample stations at that time, and in consultation with EPA, it was determined that only four wetland surface water locations would be sampled. These four sample locations are shown on Figure 14.

Detected chemical concentrations in the four surface water samples (2WSW1, 2WSW2, 2WSW3, and 2WSW6) were evaluated relative to the extent evaluation comparison criteria listed in Table 4. The concentrations listed in Table 16 exceeded their respective extent evaluation comparison values. These exceedences are also plotted on Figure 14.

As shown on Figure 14 and Table 16, wetland surface water comparison value exceedences were limited to acrolein, copper, mercury, and manganese. The lateral extent of the copper and manganese exceedences noted in Sample 2WSW6 is effectively bound by the extent of surface water within the small area of ponded water south of the former surface impoundments where this sample was collected. This area was completely dry in June 2008. The southern extent of copper and mercury in samples 2WSW1 and 2WSW2 north of the Site is defined by sample 2WSW3 where no exceedences were observed. The northern, western, and eastern extent of the acrolein, copper and mercury in sample 2WSW1 is effectively bound by the physical extent of perennial standing water in this area (i.e., standing water is not perennially present in these directions). Based on this delineation, no further investigation of wetland surface water was performed.

2.5.5 Ponds Sediments

In accordance with Section 5.6.7 of the Work Plan, sediment samples were collected from five locations within the "Fresh Water Pond" on Lot 55 in the North Area and three sediment samples were collected from the smaller pond to the southeast (referred to as the "Small Pond" hereafter). Sample locations are plotted on Figure 15. At all locations, sediment samples were collected from the 0 to 0.5 foot depth interval. It should be noted that although the name "Fresh Water Pond" has been retained to correlate with the use of this name throughout the operational history of the Site (see Section 1.2.2), field measurements of specific conductance (approximately 40,000 umhos/cm) and salinity (approximately 25 parts per thousand) indicate generally brackish water in the pond.

Detected chemical concentrations in the ponds sediment samples were evaluated relative to the extent evaluation comparison criteria listed in Table 14. The concentrations listed in Table 17

exceeded their respective comparison values. These exceedences are also plotted on Figure 15. As shown thereon, all exceedences were associated with the "Small Pond", where zinc exceedences were noted in all three samples and a 4,4'-DDT exceedence was noted in the southernmost sample. The lateral extent of these sediment exceedences are effectively bound by the limited physical extent of the pond.

2.5.6 Ponds Surface Water

In accordance with Section 5.6.6 of the Work Plan, surface water samples were collected from three locations within the "Fresh Water Pond" and three locations within the "Small Pond". Sample locations are plotted on Figure 16. As noted above, water in the "Fresh Water Pond", which was approximately 4 to 4.5 feet deep at the three sample locations, is relatively brackish. Water in the much shallower 'Small Pond" (depth of approximately 0.2 feet when sampled in July 2006 and nearly dry when sampled in June 2008) is less brackish based on specific conductance (approximately 14,000 umhos/cm) and salinity (approximately eight parts per thousand) measurements.

Detected chemical concentrations in the ponds surface water samples were evaluated relative to the extent evaluation comparison criteria listed in Table 4. The concentrations listed in Table 18 exceeded their respective comparison values. These exceedences are also plotted on Figure 16. As shown thereon, the ponds surface water exceedences were limited to total arsenic (two "Fresh Water Pond" samples), total or dissolved thallium (all samples except for one location in the "Fresh Water Pond"), total and dissolved manganese ("Small Pond" samples), and dissolved silver (all samples). The lateral extents of these surface water exceedences are effectively bound by the limited extents of the ponds.

2.6 GROUNDWATER

Groundwater investigation activities included the evaluation of the three uppermost water-bearing units at the Site, which are designated from shallowest to deepest, as Zone A, Zone B and Zone C, respectively. A brief summary of the lithology, approximate depths, hydraulic characteristics, groundwater flow directions and COI data associated with each zone is provided below. A more detailed discussion, including regional groundwater information and Site hydrogeologic cross-sections, will be presented in the RI report. Boring logs are provided in Appendix D.

An evaluation of the possible presence of non-aqueous phase liquids (NAPLs), including both light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs), in Site monitoring wells was performed as part of groundwater investigation activities. This evaluation was performed using an interface probe and/or bailer. Visible NAPL was observed within the soil matrix at the base of Zone A in the soil cores for monitoring wells ND3MW02 and ND3MW29, and at the base of Zone B in the soil core for monitoring well NE3MW30B (see boring logs in Appendix D). Soil samples were collected from these cores at ND3MW29 and NE3MW30 (Samples SBMW29-01 and SBMW30-1) respectively and analyzed for volatile organic compounds (VOCs), SVOCs, and pesticides. COIs detected in these soil samples are listed in Table 19. Monitoring well evaluations (i.e., NAPL thickness measurements using an interface probe and/or bailer) did not encounter NAPL in these or any other Site monitoring wells.

2.6.1 Zone A

Zone A is the uppermost water-bearing unit at the Site. Zone A, which consists of poorly graded sand to silty, sandy clay, is generally first encountered at a depth of 5 to 15 feet bgs (average depth of approximately 10 feet bgs). Zone A ranges in thickness from approximately 2 feet to 10 feet, with an average thickness of approximately 8 feet. Zone A investigation activities included the installation, development and sampling of 24 monitoring wells and 8 temporary piezometers, as listed in Table 20 and shown on Figure 3. Based on slug tests conducted in three Zone A wells, hydraulic conductivity values in this zone are estimated to range from 4×10^{-5} cm/sec to 8×10^{-5} cm/sec (Table 21). Groundwater within Zone A was very saline, as reflected by total dissolved solids (TDS) concentrations of 39,800 mg/L and 29,900 mg/L, in samples from wells ND3MW02 and SF6MW11, respectively.

Figures 17 through 22 depict the Zone A potentiometric surface for six water-level measurement events between October 2006 and June 2008. Water-level measurement data used to develop these figures are provided in Table 22. When measured, water-level elevations in previously existing monitoring wells (e.g., MW-1, HMW-1, etc.) were not used in contouring the potentiometric surface due to uncertainties in the construction of these wells. Overall, the Zone A potentiometric surface as depicted in Figures 17 through 22 is relatively flat with local variability indicated at individual well/piezometer locations. The figures typically show a hydraulic divide

near the center of the Site (usually in the North Area) with the groundwater flow direction generally toward the west or northwest in the area north of this divide, and generally toward the south or southeast in the area south of the divide. The June 17, 2008 potentiometric surface (Figure 22), which corresponds to a prolonged dry period, shows a generally northerly flow direction away from the Intracoastal Waterway.

Samples from the initial 17 Zone A monitoring wells (MW01 through MW17) and 8 temporary Zone A piezometers (PZ01 through PZ08) were analyzed for the complete suite of groundwater analytes as specified in the Work Plan, the FSP and the QAPP. The analytical data from these samples were used to evaluate the extent of groundwater contamination at the Site, and assess the need for additional groundwater investigation activities. This evaluation entailed a comparison to PSVs on an individual sample basis. The PSVs listed in Table 18 of the Work Plan, which consider TCEQ PCLs for Class 3 groundwater (i.e., groundwater from low-yielding units or with total dissolved solids (TDS) concentrations greater than 10,000 mg/L), PCLs for volatilization of COIs from groundwater to ambient air, and TCEQ ecological benchmark values for surface water (conservatively assuming groundwater discharge to surface water), were used for this evaluation. The extent evaluation comparison values listed in Table 23 reflect the PSVs from Table 18 of the Work Plan as updated to reflect changes in human health or ecological toxicity values since preparation of the Work Plan. TDS concentrations in Site groundwater samples were considerably higher than 10,000 mg/L in all samples, thus confirming the appropriateness of the Class 3 groundwater PCLs for this evaluation.

Detected COI concentrations in Zone A groundwater samples that exceeded Table 23 extent evaluation comparison values are listed in Table 24. As indicated therein, exceedences were predominantly for VOCs, particularly the following ten compounds:

- 1,1,1-trichloroethane (1,1,1-TCA);
- 1,1-dichloroethene (1,1-DCE);
- 1,2,3-trichloropropane (1,2,3-TCP);
- 1,2-dichloroethane (1,2-DCA);
- benzene;
- cis-1,2-dichloroethene (cis-1,2-DCE);
- methylene chloride;
- tetrachloroethene (PCE);

- trichloroethene (TCE); and
- vinyl chloride (VC).

Isoconcentration maps for these ten compounds (Figures 23 through 32) were used to project the lateral extent of contamination within Zone A. Multiple samples were collected from some Zone A monitoring wells as indicated in Table 24; in those cases, the COI concentration data for the most recent sample from that well were plotted on Figures 23 through 32.

The outermost contour lines on Figures 23 through 32 reflect the extent evaluation comparison value for the specific VOC shown on each of the figures. As shown on the figures, the concentration distribution is fairly consistent between VOCs, with highest concentrations typically observed near the southern corner of the former surface impoundments. The lateral extent of contamination, indicated by the outermost contour line, was, in all cases, limited to the North Area, and was typically limited to the southern half of the former surface impoundments area and a similarly sized area immediately to the south.

SVOCs (anthracene, naphthalene, phenanthrene, pyrene) and pesticides (endosulfan II, endosulfan sulfate, 4,4'-DDE, Dieldrin, gamma-BHC, and heptachlor epoxide) were occasionally detected in Zone A groundwater samples at concentrations exceeding extent evaluation comparison values (Table 24). These exceedences were either: (1) not confirmed by a second sample collected at that location (e.g., the endosulfan sulfate and heptachlor epoxide exceedences in the August 2, 2006 sample from SJ1MW15 were not confirmed in a subsequent sample collected from this well on June 4, 2007); (2) not confirmed by a sample from a monitoring well subsequently installed adjacent to a temporary piezometer location (e.g., the endosulfan II exceedence at NB4PZ01 was not confirmed by the sample from monitoring well NB4MW18); or (3) bounded by samples from downgradient monitoring wells that did not show exceedences of that specific COI (e.g., gamma-BHC exceedences at SF5MW10 were bounded by samples from SE6MW09, SF6MW11, and SG2MW13).

As indicated in Table 24, chromium, nickel, and silver concentrations exceeded extent evaluation comparison values in a number of Zone A groundwater samples. In all cases, these concentrations exceeded TCEQ ecological benchmark values for surface water ecological surface water criteria, but were far below TCEQ Class 3 groundwater PCLs (Table 23). As such, these exceedences are solely attributable to the conservative assumption of direct and undiluted

discharge of Site groundwater to surface water. Furthermore, the ecological benchmark values are intended to apply to dissolved concentrations in surface water rather than the total concentrations represented by the groundwater data. Considering the presence of a significant amount of fine-grained material in Zone A soils (i.e., silt or clay), it is highly unlikely that the chromium, silver, and nickel concentrations detected in groundwater samples reflect actual dissolved concentrations in groundwater that could be theoretically discharged to surface water. Even if the observed total chromium, nickel, and silver concentrations did reflect dissolved concentrations discharging to surface water, the resultant mass flux would be extremely low and would be readily diluted at the point of discharge. Thus, these ecological benchmarks for dissolved metals concentrations in surface water are not considered applicable to total metals concentrations in groundwater samples. As a result, the chromium, nickel and silver groundwater exceedences relative to ecological surface water criteria data were not used to define the lateral extent of contamination in Zone A.

2.6.2 Zone B

Based on the extent evaluation value exceedences in Zone A groundwater samples, an investigation of the next deepest water-bearing unit at the Site, Zone B, was performed. Zone B consists of a silty to well-graded sand that was generally first encountered at a depth of 15 to 33 feet bgs. The average depth to the top of Zone B was approximately 20 feet bgs. Zone B is separated from Zone A by a medium- to high-plasticity clay that ranged in thickness from approximately 2 to 7 feet. Zone B sands ranged in thickness from as little as 2 feet to as much as approximately 20 feet, with an average thickness of approximately 7 feet. Zone B was not encountered in the northwestern part of the Site in borings NC2B23B and OB26B (see Figure 3), and generally increased in thickness toward the southeast. The clay separating Zones A and B was not present at location SL8MW17 in the southeast corner of the Site.

Zone B investigation activities included the drilling of seven soil borings, and the installation, development and sampling of five monitoring wells, as listed in Table 20 and shown on Figure 3. Based on slug tests conducted in three Zone B wells, hydraulic conductivity values in this zone are estimated to range from 2×10^{-5} cm/sec to 5×10^{-4} cm/sec (Table 21). Groundwater within Zone B is also very saline, as indicated by a TDS concentration of 34,500 mg/L in a sample from well NG3MW25B.

Figures 33 through 37 depict the Zone B potentiometric surface for five water-level measurement events between June 2007 and July 2008. For the first two of these events (June 6 and September 6, 2007), a southeasterly groundwater flow direction is generally indicated. Data from the three subsequent events (November 7, 2007; December 3, 2007; and July 30, 2008) suggest a generally northwesterly flow direction.

Vertical hydraulic gradients between Zones A and B were evaluated through comparison of water-level elevations at three sets of well pairs in these units for five water-level measurement events (Table 25). In all but two of these 15 comparisons, an upward gradient from Zone B to Zone A (depicted by a negative value in Table 25) was indicated. The magnitudes of these upward gradients were relatively small, ranging from 0.02 ft/ft to 0.15 ft/ft; the two downward gradients (both for the NDMW03/ND4MW24B well pair) were also relatively small (0.02 ft/ft).

COI concentrations in the five groundwater samples collected from Zone B are listed in Table 26. Consistent with extent evaluation procedures specified in the Work Plan for groundwater-bearing units that are unlikely to discharge to surface water or sediments, the extent evaluation comparison values listed for Zone B in Table 26 do not consider ecological PSVs. As indicated in this table, the only detected concentrations exceeding extent evaluation comparison values were seven VOCs in the sample collected from well NE3MW30B, southeast of the former surface impoundments. The lateral extent of contamination is limited to NE3MW30B since there were no exceedences in samples from the other Zone B wells.

2.6.3 Zone C

Based on the extent evaluation value exceedences at NE3MW30B, an investigation of the next deepest water-bearing unit at the Site, Zone C, was performed. Zone C investigation activities included the installation, development and sampling of one groundwater monitoring well (NE4MW32C) and the installation and sampling of five Cone Penetrometer Testing (CPT) piezometers, as listed in Table 20 and shown on Figure 3. At NE4MW32C, Zone C consisted of a thin (less than 0.5 ft thick) shell layer at a depth of approximately 73 feet bgs within a high plasticity clay unit. As shown on the NE4MW32C boring log (Appendix D) and profiles for the five CPT holes (Appendix E), approximately 25 or more feet of clay/silty clay separate Zone C from Zone B (where Zone B is present). Two soil samples collected of this clay material had laboratory measured vertical hydraulic conductivity values of approximately 6×10^{-9} cm/sec

(Table 27). The TDS concentration of groundwater in a sample from Zone C groundwater from well NE4MW32C was 24,600 mg/L.

Water-level elevations measured in the Zone C monitoring well/piezometers were used to construct potentiometric surface maps for June 17 (Figure 38), July 30 (Figure 39), September 29 (Figure 40), and January 13, 2009 (Figure 41). All four of these maps suggest a generally northwesterly gradient within this unit. Vertical hydraulic gradients between Zones B and C were evaluated through comparison of water-level elevations at three sets of well pairs in these units for two water-level measurement events (Table 25). In all of these 6 comparisons, a downward gradient from Zone B to Zone C was indicated. The magnitudes of these downward gradients ranged from 0.13 ft/ft to 0.21 ft/ft.

COI concentrations in the groundwater samples collected from Zone C are listed in Table 28. As for Zone B, the extent evaluation comparison values listed for Zone C in Table 28 do not consider ecological PSVs. As indicated in this table, the only concentrations exceeding extent evaluation comparison values were 1,2,3-TCP; PCE; and TCE in the initial sample collected from monitoring well NE4MW32C, and 1,2,3-TCP in a second sample collected from this well. No exceedences were noted in two subsequent samples collected from NE4MW32C, nor were any exceedences indicated in samples from any of the five CPT piezometers. Based on the absence of any exceedences in the five Zone C piezometers, and the lack of confirmed exceedences in NE4MW32C, it is concluded that the vertical extent of contamination in Site groundwater has been defined.

2.7 CONCLUSIONS

Based on data collected as part of the Remedial Investigation for the Gulfco site, the extent of COIs in Site environmental media can be described as follows:

- Intracoastal Waterway Sediments – Certain PAHs and 4,4'-DDT were the only COIs detected in Site Intracoastal Waterway sediment samples at concentrations exceeding their respective extent evaluation comparison values. These exceedences were limited to 5 of the 17 Site Intracoastal Waterway sediment sample locations, all of which were within or on the perimeter of the barge slip areas. Based on these data, the lateral extent of contamination in Intracoastal Waterway sediments, as defined by COIs concentrations

above extent evaluation criteria, is limited to several small localized areas within the two Site barge slips. A vertical extent evaluation does not apply to this medium.

- Intracoastal Waterway Surface Water – No COIs were detected at concentrations above their respective extent evaluation criteria in Intracoastal Waterway surface water samples collected adjacent to the Site.

- South Area Soils – COIs detected in South Area soils at concentrations exceeding extent evaluation criteria included certain metals, PCBs and PAHs. The lateral extent of contamination in South Area soils, as defined by COI concentrations above their respective extent evaluation criteria, is limited to the South Area of the Site and potentially a small localized area immediately adjacent to the Site on off-site Lot 20 immediately to the west of the Site (soil data from Lot 20 suggest that an off-site COI source may be present in one or more areas of Lot 20). The vertical extent of COIs at concentrations above extent evaluation criteria in unsaturated South Area soils is limited to depths less than four feet, as no exceedences were observed in any of the samples from this depth.

- North Area Soils – The only COIs detected in at least one North Area soil sample at concentrations exceeding their respective extent evaluation criteria were arsenic, iron, lead, 1,2,3-TCP, TCE, BaP, dibenz(a,h)anthracene, and PCBs. The lateral extent of contamination in North Area soils, as defined by these few COI exceedences, is limited to several small localized areas within this part of the Site where upland soils are present (i.e., within the area surrounded by wetlands). The vertical extent of COIs at concentrations above extent evaluation criteria in North Area soils extends to the saturated zone in some locations.

- Wetland Sediments - COIs detected in at least one wetland sediment sample at concentrations exceeding their respective extent evaluation criteria included certain metals, pesticides and PAHs. The lateral extent of contamination in wetland sediments, as defined by COIs concentrations above extent evaluation criteria, is limited to specific areas within the Site boundaries and small localized areas immediately north and east of the Site. The vertical extent of COIs at concentrations above extent evaluation criteria in wetland sediments is limited to the upper one foot of unsaturated sediment.

- Wetland Surface Water – Acrolein, copper, mercury, and manganese were the only COIs detected in at least one wetland surface water sample at concentrations exceeding their respective extent evaluation comparison values. The lateral extent of contamination in wetland surface water, as defined by COIs concentrations above extent evaluation criteria, is limited to localized areas within and immediately north of the Site. A vertical extent evaluation does not apply to this medium.

- Ponds Sediment – Zinc and 4,4'DDT were the only COIs detected in at least one pond sediment sample at concentrations exceeding their respective extent evaluation comparison values. These exceedences were all limited to the "Small Pond" at the Site, which effectively defines the extent of contamination in pond sediments. A vertical extent evaluation does not apply to this medium.

- Ponds Surface Water – Arsenic, manganese, silver and thallium were the only COIs detected in at least one pond surface water sample at concentrations exceeding their respective extent evaluation comparison values. The lateral extent of pond surface water contamination, as defined by these exceedences, is limited to the extent of the two ponds (the "Fresh Water Pond" and "Small Pond") at the Site. A vertical extent evaluation does not apply to this medium.

- Groundwater – The lateral extent of Site groundwater containing COIs at concentrations above extent evaluation criteria is generally limited to a localized area within the North Area, roughly over the southern half of the former surface impoundments area and a similarly sized area immediately to the south. The vertical extent of Site groundwater containing COIs at concentrations above extent evaluation criteria is limited to the two uppermost water-bearing units (Zone A and Zone B) with criteria exceedences in two initial samples from a Zone C monitoring well not confirmed by subsequent samples.

3.0 REFERENCES

Carden, Clair A., 1982. Fish Marine Services, Freeport, Texas, Pond Closure Certification. August 18.

Gibbons, Robert D., 1994. *Statistical Methods for Groundwater Monitoring*. John Wiley & Sons, Inc.

Guevara, Jairo, 1989, Record of Communication for Reconnaissance Inspection of Former Surface Impoundments of Fish Engineering & Construction, Inc. November 28.

Hercules Offshore Corporation (Hercules), 1989. Correspondence from Raymond H. Ellison, Jr. to Jairo A. Guevara of Ecology and Environment, Inc. December 8.

Losack, Billy, 2005. Personal communications with Pastor, Behling & Wheeler, LLC. July.

LT Environmental, Inc. (LTE), 1999. Site Characterization Report. Hercules Marine Service Site Freeport, Brazoria County Texas. June.

Pastor, Behling & Wheeler, LLC (PBW), 2005. Health and Safety Plan, Gulfco Marine Maintenance Site, Freeport, Texas. August 17.

Pastor, Behling & Wheeler, LLC (PBW), 2006a. Final RI/FS Work Plan, Gulfco Marine Maintenance Site, Freeport, Texas. May 16.

Pastor, Behling & Wheeler, LLC (PBW), 2006b. Sampling and Analysis Plan – Volume I, Field Sampling Plan, Gulfco Marine Maintenance Site, Freeport, Texas. March 14.

Pastor, Behling & Wheeler, LLC (PBW), 2006c. Sampling and Analysis Plan – Volume II, Quality Assurance Project Plan, Gulfco Marine Maintenance Site, Freeport, Texas. March 14.

Texas Commission on Environmental Quality, 2004. Technical Guideline No. 3 – Landfills. Revised October 13.

Texas Department of Health (TDH), 2004. Public Health Assessment, Gulfco Marine Maintenance, Freeport, Brazoria County, Texas. Report Prepared for Agency for Toxic Substances and Disease Registry. April 19.

Texas Natural Resource Conservation Commission (TNRCC), 2000. Screening Site Inspection Report, Gulfco Marine Maintenance, Inc. Freeport, Brazoria County, Texas TXD 055 144 539. Prepared in cooperation with the U.S. Environmental Protection Agency. July.

Texas Natural Resource Conservation Commission (TNRCC), 2002. HRS Documentation Record, Gulfco Marine Maintenance, Inc. Freeport, Brazoria County, Texas TXD 055 144 539. Prepared in cooperation with the U.S. Environmental Protection Agency. February.

United States Environment Protection Agency (EPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (Interim Final). OSWER Directive 9355.3-01. EPA/540/G-89/004. October.

United States Environmental Protection Agency (EPA), 2002. *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*. Office of Emergency and Remedial Response. EPA 540-R-01-003. OSWER 9285.7-41. September.

United States Environmental Protection Agency (EPA), 2007. PRO UCL Version 4.0 Statistical software available at http://www.epa.gov/nerlesd1/ and PRO UCL Version 4.0 User's Guide. EPA 600/R-07/038. EPA Technology Support Center. Characterization and Monitoring Branch. April.

United States Fish and Wildlife Service (USFWS), 2008. National Wetlands Inventory, Online Wetlands Mapper. http://wetlandsfws.er.usgs.gov/wtlnds/launch.html. Accessed July 9, 2008.

TABLES

FIGURES

PLATE

APPENDIX A

ANALYTICAL LABORATORY REPORTS, VALIDATION REPORTS AND
ANALYTICAL DATABASE ELECTRONIC FILES
(ON DVD)

APPENDIX B

INTRACOASTAL WATERWAY SEDIMENT BACKGROUND CONCENTRATION TOLERANCE LIMIT CALCULATIONS

APPENDIX B

INTRACOASTAL WATERWAY SEDIMENT BACKGROUND CONCENTRATION TOLERANCE LIMIT CALCULATIONS

Tolerance limits were calculated for background metals analytes using the procedure described in Gibbons, 1994. Relevant pages from Gibbons, 1994 describing this procedure are attached. A step-by-step discussion of these calculations is provided below.

Step 1 - Calculate the Background Mean and Standard Deviation

After confirming the data were normally distributed, these parameters were calculated for each background metal using EPA's *PRO UCL* statistical software package (EPA, 2007). These parameters are summarized in Table B-1.

Step 2- Calculate Tolerance Limit

Since the purpose of the tolerance limit is to identify metals concentrations that are higher than background a one-sided upper tolerance limit was calculated.

As provided in Gibbons, the tolerance limit is calculated from:

TL = mean + K * (std. deviation)

Where K is a factor determined from statistical tables based on the number of samples in the background data set and the desired confidence and coverage goals. Consistent with Gibbons, 1994, a 95% confidence level with 95% coverage was used. Based on a background data set of 9 samples and these goals, and using Table 4.2 of Gibbons (attached), K was set at 3.032 for all background data sets. The resultant upper tolerance limits are listed in Table B-1.

Attachment B-1

Excerpted Pages from Gibbons, 1994

APPENDIX C

SOIL BACKGROUND CONCENTRATION TOLERANCE LIMIT CALCULATIONS

APPENDIX C

SOIL BACKGROUND CONCENTRATION TOLERANCE LIMIT CALCULATIONS

Tolerance limits were calculated for background metals analytes using the procedure described in Gibbons, 1994, and used for background Intracoastal Waterway sediments in Appendix B. A step-by-step discussion of these calculations is provided below.

Step 1 - Calculate the Background Mean and Standard Deviation

These parameters were calculated for each background metal using EPA's *PRO UCL* statistical software package (EPA, 2007). These parameters are summarized in Table C-1.

Step 2- Calculate Tolerance Limit

Since the purpose of the tolerance limit is to identify metals concentrations that are higher than background a one-sided upper tolerance limit was calculated.

As provided in Gibbons, the tolerance limit is calculated from:

TL = mean + K * (std. deviation)

Where K is a factor determined from statistical tables based on the number of samples in the background data set and the desired confidence and coverage goals. Consistent with Gibbons, 1994, a 95% confidence level with 95% coverage was used. Based on a background data set of 10 samples and these goals, and using Table 4.2 of Gibbons (see Appendix B), K was set at 2.911 for all background data sets, except for barium and zinc. The resultant upper tolerance limits are listed in Table C-1.

In the case of barium, inspection of the background data set (see Table C-2) indicates one value (1,130 mg/kg) significantly higher than the other nine values (mean of 244 mg/kg), and likely indicative of anthropogenic sources. Although EPA, 2002 does provide for consideration of anthropogenic sources not related to the site of interest when making background comparisons, for conservative purposes and based on discussions with EPA regarding the background zinc data (see below), this anomalously high barium concentration was removed from the background data set prior to calculating the barium tolerance limit. The background barium mean and standard deviation based on the remaining nine background values are listed in Table C-1. These values along with a K factor based on nine samples were used to calculate the barium tolerance limit in Table C-1.

Similarly for zinc, two values in the background data set (Table C-3) are significantly higher than the other eight values, although none of the zinc values were identified as outliers by a statistical test (Dixon's outlier test) using *PRO UCL*. Notwithstanding these findings and per discussions with EPA regarding the spatial distribution of the zinc concentrations within the background area, the two highest zinc concentrations were removed from the background data set prior to calculating the zinc tolerance limit. The background zinc mean and standard deviation based on the remaining eight background values are listed in Table C-1. These values along with a K factor based on eight samples were used to calculate the zinc tolerance limit in Table C-1.

APPENDIX D

BORING LOGS AND
MONITORING WELL CONSTRUCTION DIAGRAMS

APPENDIX E

CPT PROFILES